

BIOLOGY OF WEEDY AND INVASIVE PLANTS

Panel Manager - Dr. William E. Dyer, Montana State University
Program Director - Dr. Ann Lichens-Park

Research grants in this program support studies aimed at understanding the fundamental principles governing plant population dynamics, whether between weeds and crops in agricultural systems or between exotic and native plants in wildlands. The ultimate goal is to gain greater understanding of weedy/invasive plants and the plants with which they interact, such that plant populations can be managed more effectively. The Program also supports novel methods of controlling the spread of weedy and invasive plants, particularly those that contribute to agricultural sustainability and biodiversity of natural populations.

Emphasis in this area is on studies that will enhance understanding of how stressful interactions are established and develop between plants; how plants react to stresses generated by such interactions; weedy/invasive plant population dynamics; how weedy/invasive plant populations adapt to selection pressures, both natural and those imposed by humans; how weed populations effect crop, rangeland or forest growth, yield and quality and how invasive plants effect the biodiversity and character of natural populations.

2000-00802 Adaptive Variation and Invasive Potential of Barbed Goatgrass, *Aegilops triuncialis*

Rice, K.J.; Dyer, A.R.

University of California, Davis; Department of Agronomy & Range Science; Davis, CA 95616

Grant 00-35320-9364; \$165,000; 3 years

Barbed goatgrass, *Aegilops triuncialis* L., is a noxious annual grass that has been present in the California flora since the early part of this century, but this species has been rapidly expanding its range in recent years. The rapid invasion of rangelands by this unpalatable forage grass has increased economic loss by reducing range productivity and forage quality. In addition to invading grasslands on normal soil, this species is also capable of invading habitats generally thought to be invasion resistant. However, we know very little about the importance of adaptive evolutionary change in promoting the spread of weed populations and nothing at all about this species. In addition, the relative roles of plastic growth responses vs. genetic responses that promote weed invasions in highly variable landscapes is essentially unknown.

In this study, we will investigate the mechanisms by which goatgrass adapts to, and persists in, different rangeland environments. We will first determine the amount of quantitative and qualitative genetic variation along invasion fronts of several populations. Secondly, we will examine whether adaptive change has occurred at different locations along these fronts. Finally, we will compare genotypes from different populations to determine the specificity of local adaptation in this species. By investigating the basic genetic processes that influence survival in populations of invasive species, we will greatly improve our understanding of the invasion dynamics of weedy plants in western rangelands.

2000-00891 Invasiveness and Impact of *Ammophila Arenaria*: Release from Soil-Borne Pathogens?

Beckstead, J.

University of California, Santa Cruz; Department of Biology; Santa Cruz, CA 95064

Postdoctoral Fellowship; Grant 2001-35320-09904 ; \$89,919, 2 Years

Ammophila arenaria (European Beachgrass) is currently invading coastal sand dunes from Canada to central California. A basic tenet of invasion biology is that successful invaders are free from their natural enemies (i.e., the Natural Enemies Hypothesis). Our proposed research will directly test the Natural Enemies Hypothesis by utilizing published European research, which has established that soil-borne pathogens reduce *Ammophila*'s growth and competitive abilities in its European range, and comparing the European results with parallel studies conducted on *Ammophila* in its introduced range of central California. The objectives of this research are 1) to determine the association of soil-borne pathogens with *Ammophila* in its introduced range, and 2) to measure the effect of soil-borne pathogens

on the growth and competitive ability of *Ammophila* in its introduced range. Data from these objectives will be compared with parallel European studies to test the Natural Enemies Hypothesis. If our research finds that *Ammophila* is negatively affected by soil-borne pathogens in its introduced range (in contrast to the Natural Enemies Hypothesis), then soil-borne pathogens could be further explored as a biocontrol measure to manage the current *Ammophila* problem along the Western coast. If our research finds that *Ammophila* is unaffected by soil-borne pathogens, the release from soil-borne pathogens may explain its invasion success in its introduced range.

2000-00805 Leafy Spurge Genotype Effects on Galling by a Specialized Biocontrol Insect

Nissen, S.J.; Louda, S.M.; Lester, P.J.; Lee, D.J.

Colorado State University; Department of Bioagricultural Sciences and Pest Management; Fort Collins, CO 80523-1177

Grant 2001-35320-10020; \$200,000; 3 Years

Biological weed control has been successful in controlling a number of invasive weed species; however, a closer examination suggests that failures are often associated with weed populations that show high levels of genetic diversity. This research project seeks to improve the efficiency of biological weed control by determining the influence of plant genetic diversity and insect co-adaptation on the impact of a natural enemy against an invasive weed. Leafy spurge (*Euphorbia esula* L.) is an invasive species introduced from Eurasia in the 1700's that now infests 2.5 million acres across much of the central Great Plains and Canada. The gall midge, *Spurgia capitigena* Gagné, was one of the many insects released to control leafy spurge; however, the success of the gall midge varies with leafy spurge genotype. To test the importance of genetic diversity on gall midge success, insects for the original Italian source population and a naturalized population in North Dakota will be given access to a diverse population of leafy spurge plants from across Eurasia and from North America. We predict that the Italian gall midges will be highly successful on Italian spurge but will have varying degrees of success on other genotypes. If naturalized midges have improved success on North American leafy spurge this will be strong evidence for a shift in population structure of the gall midge to accommodate plant genetic diversity. This project will directly test the role of previous natural association and co-adaptation between the host plant and an adapted natural enemy.

2000-01211. Ecological and Genetic Determinants and Performance in a Weedy Invasive Plant

Wolfe, L. M.

Georgia Southern University; Department of Biology; Statesboro, GA 30460

Seed Grant; Grant 2001-35311-10199; \$74,262; 2 Years

One of the main threats to global biodiversity and agriculture is the invasion of alien organisms. Owing to the ecological and economic costs of biological invasions, a primary goal of research on alien species has been to understand the factors responsible for successful invasions. It is commonly noted that individuals in the introduced part of a species' geographic range exhibit exaggerated or 'weedy' growth when compared to plants in the native range. This pattern could arise if ecological conditions in the new environment are different from the native range (e.g., absence of natural enemies). Alternatively, differential performance might be due to genetic changes following invasion. The goal of my research is to examine ecological and genetic aspects of the successful invasion of *Silene latifolia*, a weedy, perennial plant. The species is native to eastern Europe and followed the westward spread of agriculture from the Middle East, eventually arriving in North America in the mid 1800s. Specifically, I propose to answer the following questions. 1) Are there genetically-based differences in life history traits between European and North American populations of the species? 2) Are there differences in the level of damage inflicted by natural enemies between European and North American populations of the species? *Silene latifolia* is attacked by at least two natural enemies (a fungus and a moth larvae) that appear to be more abundant in Europe. This research will help us understand how the underlying genetic makeup of plant species and their environment work to influence invasiveness as aliens exploit novel habitats.

2000-00882 Spatial and Temporal Breeding Dynamics of an Invasive Tree, *Albizia julibrissin*

Hamrick, J.L.; Godt, M.J.W.

University of Georgia, Departments of Botany and Genetics; Athens, GA 30602

Grant 00-35320-9372; \$205,000; 3 Years

Albizia julibrissin (mimosa) is an introduced invasive, weedy tree species that has become widespread throughout the southeastern United States during the past 150 years. We will examine several aspects of mimosa's reproductive biology to determine how characteristics of its breeding biology facilitate invasion of new habitats, establishment of populations and dispersal to new sites. We will utilize aspects of its reproductive biology that allow us to genetically identify individual pollen donors to address the following questions: Do spatially isolated trees have fewer pollen donors and experience more self-pollination than trees located within established populations? Are the majority of recruits into newly colonized sites the progeny of the initial founders of the population or does long-distance seed dispersal play a major role in population expansion and the acquisition of genetic variation? Do patterns of mating and pollen dispersal differ as populations expand or senesce? To address these questions, we have identified several spatially isolated trees and "paired trees" located in nearby populations. The availability of several years of seed collections from these trees will allow us to characterize how variation in the breeding system of mimosa facilitates the successful colonization of newly available sites. These results should provide insights into the interactions between a species' reproductive biology and its invasiveness that can be generalized to other invasive tree species with similar life history characteristics. Better understanding of the basic biological traits that make invasive tree species like mimosa successful should provide information that will allow land managers to more effectively control such species.

2000-01285 Impacts of Composted Swine Manure on Weed Seed Survival, Seedling Emergence, Growth, and Competitive Ability

Liebman, M.; Buhler, D.D.

Iowa State University; Department of Agronomy; Ames, IA, 50011-1010

Grant 00-35320-9328; \$205,000; 3 Years

Because of their seed bank and fixed root habits, annual weeds are highly responsive to soil conditions. The goals of this project are (1) to identify how amending soil with composted swine manure alters weed population dynamics, weed community composition, and weed-crop interactions, and (2) to determine the influence of weed seed size and seedling emergence order on responses to soil conditions. Two field experiments, a laboratory bioassay experiment, and a glasshouse experiment will be conducted to examine compost effects on seed and seedling survival, establishment, growth, and competitive ability of ten weed species commonly infesting Midwestern U.S. corn and soybean fields. We will use species spanning a range of seed weights and seedling emergence times because we believe those are key factors affecting the structure and function of weed communities.

The compost used in this study will be produced in hoop structures that are increasingly popular with Iowa farmers because of low capital investment costs, lower risks of water contamination, and reduced odor emissions. As more farmers adopt this new animal husbandry technology, information will be needed concerning how composted swine manure affects weed community composition and weed-crop interactions. Our collaboration with a microbiologist, a soil scientist, and an agricultural engineer will provide insight into the biological, chemical, and physical mechanisms affecting weed responses to compost and altered soil conditions. The project represents a unique opportunity to study the integration of weed and soil management in a manner that can improve soil quality while reducing threats of water and air pollution. The information generated will stimulate further efforts to link livestock and crop production, and soil and weed management, through compost production and utilization.

2000-00901 Site-Specific Weed Management in the Midwestern Corn and Soybean Belt

Medlin, C.R.

Purdue University; Department of Botany and Plant Pathology; West Lafayette, IN 47907-1155

New Investigator Award; Grant 2001-35320-10021; \$100,000; 2 Years

The USDA, FDA, and EPA have pledged to reduce pesticide use and associated health and environmental risks. Since weeds are by far the most important pests in U.S. agriculture, reducing herbicide use in U.S. agriculture is a major priority of these agencies. The development and implementation of herbicide applicators, activated only by weed presence, is the key for these agencies to successfully reduce herbicide use. The research proposed will investigate methods of using state-of-the-art remote sensing technology recently developed at Purdue University to identify reflectance response ranges of the most common weed species found in Midwestern corn and soybean fields when subjected to commonly used soil-applied herbicides. Also, weed population maps will be constructed for the surrounding fields by intensively scouting and marking weed populations, by species, with highly accurate global positioning equipment. These weed population maps will be used to (1) ascertain the level of precision in mapping necessary to effectively use a herbicide recommendation program on a field basis, and (2) determine the impact of aggregated weed populations on yield loss prediction from a herbicide recommendation program. Ultimately, the proposed research will benefit (a) crop producers by providing them with an economic comparison of automated spot spraying versus broadcast spraying for weeds, (b) County Extension Educators and agribusiness personnel by educating them and their clientele about the most economical weed management practices available, and (c) the environment by reducing herbicide use.

2000-01215 Quantitative Genetic Architecture and Plasticity Of Seed Dispersal In *Arabidopsis thaliana*

Donohue, K.

University of Kentucky; T. H. Morgan School of Biological Sciences; Lexington, KY 40506

Seed Grant; Grant 2001-35311-09845; \$75,000; 2 Years

The ability to disperse seeds efficiently is one characteristic that defines a weedy or invasive plant. Understanding the ecological and genetic mechanisms that determine seed dispersal ability is fundamental for efforts to predict or control the spatial expansion of undesirable plant species or genotypes. This research focuses on the genetic and environmental influences on seed dispersal in *Arabidopsis thaliana*, a model system for genetic studies. This research will determine the extent to which seed dispersal has a genetic basis, how the genetic component of seed dispersal varies with the environment, and what other characters are correlated with seed dispersal. In addition, a genetically variable population will be created for artificial selection studies that will increase and decrease dispersal. In future studies, use of these artificially selected populations will enable the genetic basis of reduced dispersal ability to be analyzed in detail, and the possible side-effects of decreased dispersal ability will be identified. Knowledge of the genetic basis of seed dispersal is important for future efforts to genetically manipulate dispersal ability in crop plants. It would be particularly useful for controlling dispersal of genetically modified plants. In addition, knowledge of the degree of genetic variation in seed dispersal in natural populations of weedy species, and its lability in response to different ecological conditions, is essential for predicting whether weedy behaviors will become more problematic in the future due to responses to natural selection on dispersal.

2000-00886 Invasive Versus Native Plants: Resource-Use Efficiency, Plasticity and Survival

Harrington, R.A.; Fownes, J.H.

University of Massachusetts, Amherst; Department of Natural Resources Conservation; Amherst MA 01003

Grant 00-35320-9089; \$250,000; 3 Years

Non-native species may invade native communities where they pose a serious threat to native biodiversity. We are using a combination of field observations and two controlled experiments to assess the effect of light and nitrogen availability on leaf photosynthetic characteristics, plant biomass allocation, growth rate and survival. This study includes a contrasting set of invasive and native trees and shrubs in New England forest ecosystems. Invasive species will be *Ailanthus altissima* (shade-intolerant tree), *Acer platanoides* (shade-tolerant tree), *Eleagnus angustifolia* (shade-intolerant shrub) and *Berberis thunbergii*

(shade-tolerant shrub). Native species will be *Betula papyrifera* (shade-intolerant tree), *Acer saccharum* (shade-tolerant tree), *Vaccinium corymbosum* (shade-intolerant shrub), and *Hamamelis virginiana* (shade-tolerant shrub). We will test ideas that invasive trees and shrubs succeed because (1) they use light and/or nitrogen more efficiently than the native species, (2) they are able to thrive in more diverse habitats than native species, (3) they are subject to fewer environmental constraints than native species, or (4) they survive in certain habitats better due to defense against browsing. The results will extend our fundamental knowledge of plant ecology, and identify the potential susceptibility of local habitats to invasion, and help prioritize control and removal efforts.

2000-00842 Effects of Species and Functional Diversity on Invasions in Grasslands

Brown, C.S.

University of Minnesota, Twin Cities; Department of Ecology, Evolution and Behavior; Saint Paul, MN 55108-6097

Postdoctoral Fellowship; Grant 2001-35320-09842; \$89,447; 2 Years

The notion that more diverse plant communities are less easily invaded by new species, the diversity-invasibility hypothesis, has become popular in ecology and is supported by both theoretical and experimental work. However, the results of some experiments indicate that the composition of communities is a more important determinant of invasibility than species diversity, which has created vigorous scientific debate. The proposed research will test the diversity-invasibility hypothesis by introducing seeds and seedlings of different types of herbaceous plants, or functional groups, into existing experimental plant communities. The existing experiment is designed to test the effects of functional group composition and species diversity on community and ecosystem functioning. The invaders will be planted into existing experimental communities of five levels of functional group diversity and five levels of species diversity. This experiment will address the questions: (1) Are plant communities with greater numbers of species and functional groups less easily invaded than communities with fewer species and functional groups? (2) Is the functional diversity of the resident community a more important determinant of invader success than its species diversity? (3) Is species or functional group identity more important than diversity in determining success of invaders? (4) What traits of invaders, relative to traits of the resident species, allow invasion to occur? Results will help identify general mechanisms that control plant invasions, which can benefit the long-term success of United States agriculture through improved invasive species management in rights-of-way, rangelands and natural areas.

2000-00895 AM Fungi: Effects on Biology and Community Dynamics of Weeds

Jordan, N.; Zhang, J.; Kurle, J.E.

University of Minnesota, St. Paul; Department of Agronomy and Plant Genetics; St. Paul, MN 55108

Grant 2001-35320-09852; \$190,000; 3 Years

Arbuscular-mycorrhizal fungi (AMF) infect roots of most vascular plants, and strongly affect individual plant biology and ecological relationships of plants with many other organisms. AMF usually have valuable effects on farms, increasing crop production and reducing soil erosion. Conservation-tillage farming methods reduce soil disturbance and increase the diversity and abundance of AMF on farms. These changes in AMF are likely to affect weeds that hinder crop production. First, AMF have recently been shown to strongly inhibit the growth of a variety of unrelated weed species, suggesting that AMF may provide farmers with a valuable new method of non-herbicidal weed control. Also, AMF may help sustain certain weeds that are ecologically useful to farmers. These weeds help farmers by providing soil protection, limiting water pollution by fertilizers, and by providing habitat for other beneficial organisms. However, knowledge of interactions between weeds and AMF is very limited. We will increase that knowledge by examining effects of AMF on the biology of individual weeds species and on weed communities, using field and greenhouse studies. We will assess how growth, reproduction and stress tolerance of a variety of weeds are affected by AMF. In these studies, we will systematically assess whether AMF can be used as a broadly-applicable method of biological weed control. We will also test whether AMF can increase the proportion of ecologically-useful weeds in weed communities. If AMF

has this effect, then farming methods that encourage AMF may cause weeds to become less of a problem for farmers.

2000-00836 Origins of Invasive *Tamarix* Inferred From DNA Sequence Data

Schaal, B.; Gaskin, J.

Washington University, St. Louis; Department of Biology; St. Louis, MO 63130

Grant 00-35320-9434; \$90,000; 2 Years

The second worst plant invasion in the U.S. consists of species from the genus *Tamarix* (*Tamaricaceae*). These rapacious weeds are displacing native species and degrading natural habitats on over 1,000,000 riparian acres in the southwest, and the invasion is expanding by over 50,000 acres per year. The specific identities and invasive histories of *Tamarix* are not well documented in horticultural or import records. We will use interspecific and population level DNA sequence analysis from Eurasian and U.S. invasive specimens to 1) determine taxonomic status of *Tamarix* invasions, 2) locate the Eurasian source populations and 3) determine if post-introduction hybridization has produced novel genotypes associated with an increase in invasiveness. Invasions of nonindigenous species into natural habitats are now considered the second largest ecological disaster worldwide. In addition to the \$137 billion per year economic cost of nonindigenous species on our nation's agriculture, forestry, and public health, approximately 400 of the 958 species that are listed by the Endangered Species Act are at risk primarily due to competition with and predation by nonindigenous species. The histories of invasive species, including their geographic origins, number and location of introductions, and detection of genotypes unique to the introduction, will add critical insight to our knowledge of invasion processes. This information is also essential for invasive species that are targets of biological control, and will expedite and enhance worldwide searches for successful control agents.

2000-00985 Cell Biology of the Dodder Haustorium

Vaughn, K.C.

USDA-ARS; Southern Weed Science Research Unit; Stoneville, MS 38776

Grant 00-35320-9091; \$42,350; 3 Years

Dodders are the most economically-important group of parasitic weed species in the world. Virtually every cropping situation and natural sites has some species of dodder, which is responsible for reduced crop yield and/or loss of susceptible native plant species. Once dodder is found in an area, it is very difficult to control as seeds may sprout for up to forty years after infestation. Despite the importance of dodders in terms of agriculture and native plant loss, little is known of how the dodder actually attacks the host plant and sets up this parasitism. This grant seeks to understand the mechanisms by which dodder is able to invade a susceptible host species. Using a diverse series of microscopes and unique ways of probing the dodder, we should be able to determine several facets of the dodder's life history that could make control of this pernicious weed easier. For example, the dodder is able to adhere to the host stem or leaves but the substance that causes them to adhere is unknown. Similarly, the dodder seems to be able to grow both through and in between the cells of the host, although how it is able to do this is unknown. After the successful invasion, the dodder is then able to draw its sustenance from the host by establishing a new vascular system out of cells that were initially involved in penetrating the host. Again, the mechanism(s) that trigger these changes in development are also unknown. Conceivably, finding any way of blocking any of these various facets of dodder development would protect the host plant from this pernicious group of weeds.

2000-00980 Methods for Improving On-Farm Weed Management Decisions

Maxwell, B.; Bussan, A.; Buschena, D.; Goodman, D.

Montana State University, Bozeman; Department of Land Resources and Environmental Science; Bozeman, MT 59717

Grant 00-35320-9464; \$90,000; 2 Years

The increased use of farming equipment that records the spatial location of crop yield provides a massive amount of data that may be used in making production decisions that are optimal for individual producers. Our project will use spatial yield and weed information gathered on five wheat farms over several years to assess where and when it is advantageous for a farmer to apply pesticides. Decision making based on locally obtained data, combined with an economic assessment of risk, may prove to be more accurate and convincing than modeling efforts aimed at having regional generality. Our approach therefore has the capacity to reduce pesticide usage over full-field application resulting in more ecologically sustainable production systems. We will use a Bayesian analysis that enables producers to continually improve weed control decisions as additional data is gathered. Our analysis will determine the degree of model complexity and amount of weed sampling necessary for the optimal feed-back between precision yield data and local decision making. We will further determine the usefulness based on performance comparisons between experiment farm derived predictions and on-farm analysis.

2000-00799 Symposium on Seeds and Vegetative Propagules

Foley, M.E.

USDA Agricultural Research Service; Red River Valley Agricultural Research Center; Biosciences Research Laboratory; Fargo, ND 58105-5674

Grant 00-35320-9337; \$5,000, 1 Year

Weeds are the major pests in agricultural and natural ecosystems that adversely impact human endeavors in numerous ways. With the goal of improving existing and devising new weed management strategies, scientists are investigating biological characteristics of weeds and other plants. One such characteristic is arrested growth and development or dormancy. Dormancy of seeds and vegetative buds occurs in most plants. In weedy plants, these characteristics increase their survival, persistence, and invasive potential. A great deal of the contemporary research on dormancy is conducted on plants other than weeds. To update the weed science community, stimulate interest in conducting fundamental investigations of dormancy in weeds, and foster interaction between weed scientists and scientists from other disciplines, a symposium on dormancy in seeds and vegetative propagules will be held at the annual meeting of the Weed Science Society of America in Greensboro, NC in February 2001. The symposium will feature speakers from a variety of disciplines who are conducting fundamental biological research on dormancy in seeds and vegetative propagules in various plant species. Written proceedings from the symposium will be published in *Weed Science* to serve as a lasting resource for students, teachers, and researchers.

2000-00848 Herbivore-mediated Indirect Effects of an Exotic Thistle on Native Thistles

Louda, S.M.

University of Nebraska, Lincoln; School of Biological Sciences; Lincoln, NE 68588-0118

Grant 2001-35320-09882; \$210,000; 3 Years

This project will quantify the indirect impact of an invasive weed on two native plant species by its effect on a shared insect herbivore. The project takes advantage of the opportunity provided by the host range expansion of the biocontrol weevil, *Rhinocyllus conicus*, onto native thistles (*Cirsium* spp.) in prairie rangelands. Data from 1999 suggested that *R. conicus* may reduce its use of the native plants when its preferred, exotic host plant, musk thistle (*Carduus nutans* spp.) is nearby. In this study, we will evaluate the generality of this observation, develop a better understanding of insect-mediated indirect interactions between plants, and study harnessing that knowledge to manage the impact of this insect on rare native plants. We will quantify insect use and do two experiments to answer three fundamental questions: 1) how are seed losses of native thistles related to the rangeland type and the ecological characteristics of the weed stand?; 2) does proximity of the preferred weed species increase or decrease impact on native plants?; and, 3) can ecological factors be manipulated to minimize negative impacts on rare native species? The hypotheses to be tested are that the occurrence of musk thistle: (H_1) has no effect, or (H_2) decreases (= "associational defense"), or (H_3) increases (= associational susceptibility") seed loss of the native. The results will contribute to a basic understanding of herbivore-mediated interactions

between weeds and native plants and to the application of such understanding in the management of invasive exotic species.

2000-00884 Spatial Distribution of Weed Patches: the Influence of Habitat Heterogeneity

Mortensen, D.A.; Neeser, C.

University of Nebraska; Department of Agronomy; Lincoln, NE 68583-0915

Grant 00-35320-9376; \$160,000; 3 Years

Farmers, consultants, and land managers have always recognized heterogeneity within fields and across fields within a farmstead. Most agree that heterogeneity has increased as smaller fields have been incorporated into larger ones and as the complexity of crop rotations have decreased. Weed populations are known to be patchy though a full understanding of the causes of this patchiness is lacking. From a practical point of view farmers could learn about weak links in management practices or strategies if the mechanisms giving rise to patchiness were understood. A body of evidence points to several causal factors including: density dependent mortality (the more weeds you have the less well a weed control practice works); strong associations of weed populations and field site characteristics; and the influence of dispersal in space and time (weed seed dormancy). We believe understanding why weeds occur where they do and where they don't, as well as factors regulating weed persistence, enhance our ability to evaluate the impact of present and future weed management strategies. We will therefore assess the influence of habitat suitability on plant fitness and patch fate through a set of field experiments and through model simulation. Through this project, an increased understanding of the importance and interplay of density dependent mortality, habitat suitability and dispersal will be gained by empirical studies and model simulation. The spatially explicit model developed in the project can be used as an organizational framework for assessing alternative management strategies, targeting life-stages particularly important in regulating population size.

2000-00885 The Application of Resource Competition Theory and Keystone Herbivory to Plant Invasions: Towards a Predictive Theory

Carson, W.

University of Pittsburgh; Department of Biological Sciences; Pittsburgh, PA 15260

Grant 00-35320-9090; \$200,000; 3 Years

We currently do not have the ability to evaluate the potential of biological control agents such as insects to stop the spread of introduced plant species. Consequently, we cannot identify invaders before they become pests even though invasive plant species have long been recognized as a threat to agriculture. Past efforts to identify potentially invasive plants have focused primarily on the growth characteristics of weeds of successful invaders. This approach has produced important generalizations about invasive species, yet it cannot explain how invasions occur. Additionally, these approaches cannot determine whether a biological control agent is likely to stop the spread of an invader. Here, we propose a potential remedy to this difficult and long-standing problem. We plan to study exactly how native plants compete with introduced plants. We will determine if an invader is successful because it outcompetes a native plant species specifically via the invaders ability to deplete the level of the shared limiting resource (e.g., soil nitrogen). Furthermore, we will determine whether a biocontrol agent (e.g., a plant-eating insect) is effective only when it prevents the invader from depleting the shared limiting resource. Additionally, we will try to determine the dose of the biocontrol agent (number of insects) required to stop the invader. We will study the invasive plant purple loosestrife, its primary native competitor, broad-leaved cattail, and two plant eating insects. If we understand exactly how introduced weeds spread and displace native plant species, more effective means of weed control can be devised.

2000-00843 Gene Flow and Hybridization Between Jointed Goatgrass (*Aegilops cylindrica* Host) and Wheat (*Triticum aestivum*)

Mallory-Smith, C.; Riera-Lizarazu, O.; Morrison, L.

Oregon State University; Department of Crop & Soil Science; Corvallis, OR 97331-3002

Grant 2001-35320-09918; \$250,000; 3 Years

Jointed goatgrass is a major weed pest in winter wheat fields. This species (*Aegilops cylindrica* Host) is a wild relative of wheat (*Triticum aestivum* L.). It entered the United States during the late 1800's and early 1900's as a contaminant of wheat seed from Europe. Unknowingly, immigrants brought it to the Midwestern states and the USDA introduced it in cultivars obtained for plant breeding research. Over the last century this weed has spread across the United States, now infesting over 5 million acres of agricultural land and causing annual losses of \$145 million. Jointed goatgrass now poses a potentially more serious weed problem because it can form fertile hybrids with wheat. Since herbicide-resistant wheat currently offers the most promising control method, the possibility of the herbicide-resistant gene moving into jointed goatgrass threatens the success of this new control option. Using the tools of molecular genetics, this research takes the essential first steps in understanding the nature of the hybrid problem by (1) characterizing the genetic diversity in jointed goatgrass using native material from Asia and Europe and weed material from Oregon; (2) determining if jointed goatgrass acts as the female and/or male hybrid parent; (3) studying the ability of genes to move from wheat to jointed goatgrass. Evidence produced by this work will help assess the extent to which hybridization contributes to the jointed goatgrass weed problem. It also will provide the information essential for future risk assessments of gene flow from transgenic wheat to jointed goatgrass.

2000-00978 Population Dynamics, Competition, and Biodiversity Impacts of an Invasive Grass

Fowler, N.

University of Texas at Austin; Section of Integrative Biology; Austin, Texas 78712

Grant 2001-35320-09917; \$240,000; 3 Years

The number and abundances of non-native naturalized plant species are increasing and the problems they cause are becoming more apparent. Even 'desirable' non-native species may have negative effects, especially upon native biodiversity. One of the first 'old-world bluestem grasses' to be widely planted in Texas was King Ranch bluestem, *Bothriochloa ischaemum*. This non-native grass is now fully naturalized (i.e., it spreads without human intervention). It is highly tolerant of grazing, but can also increase in abundance in ungrazed sites. It reduces the abundance of other species of plants substantially, and therefore is considered an undesirable species where preserving biodiversity is a management goal. No methods of control are known. This project will develop biological knowledge to manage this species. Furthermore, because this is the only common non-native plant species in the otherwise 'natural' vegetation of the eastern Edwards Plateau of central Texas, this investigation of the interactions between King Ranch bluestem and native plant species will identify factors that permit plant species to invade and then to dominate plant communities. The project asks (1) What are the impacts of King Ranch bluestem on the abundances of other plants, in different habitats and under different grazing regimes?; (2) What are the ecological requirements of King Ranch bluestem seedlings and juveniles?; (3) What are the effects of fire and of competition on King Ranch bluestem?; and (4) How do the effects of competition depend upon the grazing regime? These questions will be answered with field and garden experiments and observations.

2000-01286 QTL Analysis of Traits that Limit the Ecological Range of Cattails

Stratton, D.A.

University of Vermont; Department of Botany and Agricultural Biochemistry; Burlington, VT 05405

Grant 00-35320-9335; \$247,650; 3 Years

Genetic changes in tolerance limits may allow plant species to invade previously unoccupied environments. Two models for the genetic control of tolerance curves make different predictions about the long-term limits to range expansion in invading species. One model assumes tradeoffs in performance in different habitats. Another assumes conditional expression of deleterious mutations at different loci in different environments. Our recent ability to identify regions of the genome (QTL) that cause differences

in performance across environments now allows us to differentiate those models by testing patterns of expression of QTL along environmental gradients.

Two species of common cattail, *Typha latifolia* and *Typha angustifolia*, are aggressive dominants in wetland communities. Cattails represent an unusually well-studied system where the environmental controls on distribution are understood and can be easily manipulated. The two species will be crossed and genetic markers will be used to produce a linkage map of the genome. Replicates of those lines will be grown along environmental gradients that are known to control the ecological range of cattails. Tests for the linkage of genetic markers to variation in drought tolerance, flooding tolerance and salinity tolerance will identify gene regions that control the ecological distribution of cattails. Measures of the effects of those genes on the shape of the tolerance curve will be used to test whether genetic effects on fitness change sign (tradeoffs) or whether they fit threshold models (conditional expression). By understanding the genetic forces that shape the tolerance limits of these species, we will better understand the evolutionary processes that limit the distribution and abundance of plants in general. For example, if most loci that control distribution limits are conditionally expressed, then it may be possible for species to expand into new habitats without reducing their fitness in the original environment.

2000-01281 Using Exotic Weedy Invasions to Select Competitive Ability in Native Species

Hild, A. L.

University of Wyoming; Department of Renewable Resources; Laramie, WY 82071

Seed Grant; Grant 2001-35311-09846; \$74,965; 2 Years

Exotic weedy species invasions have limited the agricultural productivity of North American wildlands and revegetation efforts require us to identify promising native seed sources. Although revegetation on public lands often requires replacement of native plant species, availability and success rates of native seed sources are limited. Additionally, managers lack sufficient native species that are known to resist exotic invasions and which can compete successfully in revegetation plantings. We suggest that exotic weeds can serve as selective agents that improve the competitive ability of remaining native plants that are found to survive in the presence of weed invasions. We will examine native genotypes found in natural settings in Idaho and Wyoming where invasions of such weedy species as Russian knapweed, leafy spurge, downy brome and perennial pepperweed occur. The ability of isolated native plants to grow in the presence of exotics may identify particularly useful competitive qualities in these individuals. By using seed from these persistent natives, we will examine their ability to compete with the exotics in controlled greenhouse settings and in replanted field sites. Transfer of especially competitive native genotypes to production for revegetation efforts could greatly enhance our ability to limit further exotic encroachment. In addition, future work with these species can help revegetation efforts to return native genetic diversity and agricultural productivity to many rangelands.